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FEATURES OF THE METHODOLOGICAL APPROACH TO THE EVALUATION OF THE LED LIGHTING EFFICIENCY IN THE INDUSTRIAL PREMISES

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ABSTRACT

This article considers the issues related to research on the LED lighting efficiency in the industrial premises, the need to use the methodology to obtain meaningful scientific results. The LED lighting efficiency should be determined, primarily, based on the creation of conditions that are optimal for visual activity and safe from a hygienic standpoint. We showed the main problem in substantiating the areas of LED lighting application, which is related to the specific character of spectral emission structure of the white LEDs and the photo biological effects of its individual sections. We specified the need for an integrated approach for the efficiency assessment. Luminescent lighting is suggested as a basis for comparison, as the most studied from the position of influence on various indicators that determine hygienic effectiveness, as well as the visual working capacity of a person. We highlighted the need for carrying out studies of a reasonable choice of illumination indices - the ranges of illumination and color temperatures. We considered the approaches to the choice of research methodology. We proposed to evaluate the main functional indicators of the state of the organ of vision and the human body as a whole, the dynamics of visual performance and visual fatigue in the experimental material for lighting implementation with LED light sources in the industrial premises.

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Key words: methodology, LEDs, lighting, problem, efficiency, scientific approach, complex methodology, experimental studies, illumination, color temperature, visual functions, fatigue, recommendations.

INTRODUCTION

The methodology is considered as a subjective process, that is, as an activity for obtaining new scientific knowledge [1]. However, not all activities need the application of methodology, but they play a crucial role in achieving the goals in the research activities.

The modern scientific research in the field of lighting installations is aimed at an objectively new result, that is, a psychophysiological and hygienic assessment of the possibility of applying modern technical developments to create comfortable lighting conditions, determining the optimum application areas for new light sources and lighting systems based on them for performing various visual tasks, obtaining material for the development and improvement of regulatory documentation in the field of lighting, etc.

The purpose of our study is to evaluate the effectiveness of LED lighting in the industrial premises to create conditions that are optimal for human visual activity and safe from a hygienic standpoint. On the one hand, the research goals can be considered as current, since LED lighting is already widely used, on the other hand, they can be considered as promising, which open up new possibilities in lighting technology [2, 3].

The main part of the article

The methodology of any research begins with the selection, setting and formulation of its purpose. The study subject is the lighting systems based on LED light sources, used in the industrial premises for various special purposes. In the energy saving conditions, it is necessary to investigate the technical and operational characteristics of LEDs, light devices and lighting installations based on them, to find new ways to increase their energy efficiency. In this case, the fundamental element of the system is a person. His working capacity determines the production activity efficiency - labor productivity, efficiency of production processes. But, on the other hand, it is obvious that one cannot solve these problems in isolation from the influence on the person of all the factors associated with the operation of these promising light sources.

The key point in the research is the identification of the main problem. There is a problem that needs to be resolved in the studies on the LED lighting efficiency. This problem is related to the spectral emission structure, namely, the high intensity of the radiation flux in the blue part of the spectrum, which is necessary to obtain a white LED glow.At present, there is a wide

range of opinions on optimizing the LED lighting conditions, as well as on the medical and biological aspects of the effect of LED light emission on the organ of vision, the psychophysiological state and general physical health of a person [4-7]. Some experts express their fears about the consequences of long exposures, the total result of which can affect only in years.

As is well known, the photobiological effect of light on the human body includes psychophysiological effects, including visual sensations, emotional states, tonic, therapeutic and destructive effects that may manifest themselves, for example,in possible damage to the elements of the eye and skin and the long-term effects on physical health in general (the so-called photobiological danger).

Recently, there have been quite a few publications devoted to the effect of visible light color, including the medium blue part of the spectrum, on the melatonin secretion and related problems with human health. It is known that light entering the human eye causes a number of biological and behavioral effects - the secretion of melatonin and cortisone, circadian changes.

The structure of natural eye protection systems from photodamage includes several independent mechanisms, which include the optical eye color filters - cornea, lens, screening pigments. They cut off dangerous short-wave radiation - ultraviolet and partially blue - from the retina and pigment epithelium. A key role is played by the lens. Its properties vary throughout the life of a person. In infancy, the lens has an ultraviolet "window" that transmits a certain part of the ultraviolet radiationto the retina. The purpose of this window remains unclear. When a person reaches approximately 15 years old, the "window" disappears and then a gradual yellowing of the lens occurs, which is most pronounced in old age. In general, the analysis of data on the damaging effect of light on the retina and on the spectral properties of light protection of the eye suggests that a significant attenuation of radiation is necessary in the spectral part with wavelengths shorter than 450-460 nm (blue radiation) [8, 9].

An important part in the content of the research methodology is the approach. The approach is the view from which the research begins and which determines its orientation with respect to the goal. We chose the scientific approach as the most effective one. It is characterized by the scientific setting of research objectives and the use of a scientific apparatus in its conduct. When studying the LED lighting efficiency, we found out that the most effective approach was the complex study of physiological functions, in which the results obtained with the help of various methods complemented each other and diversified the state of the organ of vision and the human body as a whole.

The research methodology should include the definition and formulation of benchmarks and constraints. They allow conducting research more consistently and purposefully. We offer to select luminescent lighting as a basis for comparison, as the most studied from the position of influence on various indicators that determine hygienic effectiveness, as well as the visual working capacity of a person. Lighting, created by incandescent lamps is unpromising due to low energy efficiency as a comparison base, although it continues to be used in individual cases, for example in household lighting.

A reasonable choice of the range of illumination and color temperatures is required for research. Of course, the wider the range of illumination values are (at which the studies will be carried out), the greater the amount of experimental material can be obtained for analysis. However, the costs and time allocated for the experiment can be an important factor. The choice of illumination values is carried out in accordance with the scale [10], depending on the nature of visual works. For example, the illumination of working surfaces is usually 100-1,000 lux for the residential and basic premises of public buildings. Illumination of the premises of industrial enterprises, depending on the nature of the visual works performed and the lighting system, requires higher levels of illumination. It is necessary to take into account such factors as background characteristics, contrast values, etc. The low voltage incandescent lamps continue to be used as a source of light for local lighting (in various types of equipment - machines, automation devices, presses, etc.).

The choice of the range of color temperatures in studies is determined by the type of visual tasks associated with or unrelated to the requirements for color perception. According to [10], it is recommended to use light sources with a color temperature from 2,400 to 6,800 K for artificial illumination.

The responsible stage of work is the choice of research methods, from the correctness of which the achievement of research goal largely depends. We confirmed the necessity of using methods of related sciences in the scientific research in practice. In our opinion, the materials of psychophysiological studies, the evaluation of the main functional indicators of the state of the organ of vision and the human body as a whole, the dynamics of visual performance and visual fatigue under LED lighting are of special interest for determining the LED lighting efficiency. The data obtained in the course of experiment make it possible to compile a psychophysiological "portrait" of fatigue development and to evaluate the effectiveness of the illumination options compared. At the same time, it is necessary to take into account the nature dynamics and absolute (or relative) values of the functional indicators.

A feature of modern scientific research is that they are based on the criteria of objectivity, as well as on the totality of works of domestic and foreign scientists. Based on this, we carried out an analysis of the theoretical material and experimental studies of the impact of various factors, primarily those related to illumination, on the functional parameters of the organ of vision and the human body as a whole, which allowed us developing a comprehensive methodology for assessing the LED lighting efficiency [11]. The experimental method includes the following studies of the:

- functional state of the organ of vision;
- functional indicators of the state of human body;
- integral indicators of the effectiveness of visual performance and visual fatigue.

Research of the LED lighting efficiency assumes the use of modeling as a method of scientific research. In our case, a specially designed and created experimental research facility that implements lighting options with LED and basic light sources is used to investigate the LED lighting efficiency in the industrial premises. The studies also use models of different types of visual work, depending on the purpose of the industrial premises [12, 13].

The Materials of experimental research should show how the light affects the organ of vision and the human body as a whole, the integral indicators of visual performance.

SUMMARY

To confirm the conclusion about the LED lighting efficiency, it is necessary to conduct a full-scale experiment in the industrial premises of enterprises. The results of these studies will create a scientific and methodological basis for the standardization of lighting by LED light sources for general industrial productions and facilities, as well as for industry standardization. The introduction of changes to the current regulatory documentation will improve the energy efficiency of lighting, its quality and hygienic safety.

CONCLUSIONS

Thus, in order to carry out the experimental studies of the LED lighting efficiency, it is necessary: to substantiate the methods and approaches that take into account the specific character of production activities; to select the efficiency criteria for industrial lighting systems with LED lighting; to create an experimental research of the facility that implements lighting options with LED and basic light sources; to develop a plan and methodology for the experiment; to train the observer groups; to carry out the experimental studies in laboratory and field conditions. The analysis of the obtained research results will make it possible to

evaluate the efficiency of the LED lighting conditions for industrial premises for various special purposes and to develop a comprehensive efficiency indicator.

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